The Molecular Universe unravelled by innovative THz laboratory techniques

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Description: How do we connect the life on Earth to the formation of the simplest molecules detected in space? Understanding how complex organic molecules (COMs) form and survive throughout the process of star and planet formation is a key step towards finding the answer to this question. Although mainly observed in the gas phase, COMs cannot be efficiently formed through gas-phase reactions but must form on icy dust grains that work as catalytic sites, where molecules meet and react. Recently, the Atacama Large Millimeter/submillimeter Array (ALMA), with its exceptional sensitivity and resolving power, and the soon-to-be-launched James Webb Space Telescope (JWST) are expected to give us an unprecedented view of COMs in the gas (ALMA) and solid (JWST) phases in various astrophysical environments, where molecules are exposed to thermal and (non)energetic processing. A complete interpretation of these data will require the exploitation of new laboratory techniques that will allow a better understanding of the chemistry and physics leading to the formation and implementation of COMs in solar-like systems. THz spectroscopy is a new methodology that opens a new era of astronomical and laboratory observation since it explores the ro-vibrational transitions of larger gas-phase species, interlayer vibrational and single molecule torsional modes of ices, and phonon modes in solids. THz spectra of solid molecules provides direct information on the structure and physical properties of ices. Moreover, time-resolved THz spectroscopy will allow us to understand the physics and chemistry of the interstellar medium because it will allow the first direct investigation of molecular mobility and reaction dynamics within condensed matter at very short timescales.

The OU Astrochemistry research programme focusses on the investigation of the physico-chemical properties of astrochemical ices under controlled laboratory conditions using (ultra)high vacuum and cryogenic techniques to grow interstellar ice analogues. At the OU, the use of portable (U)HV chambers allows for the investigation of different processes within the ice via access to large facilities such as the free-electron lasers (FELs) FELIX (Radboud University, Netherlands) and ALICE (Daresbury Laboratories, UK). The successful candidate will be involved in ongoing research projects carried-out at the OU Astrochemistry lab and at world-leading FELs to systematically explore the effect of selective radiation of IR/THz modes in ices. We seek a highly motivated candidate with an interest in astrochemistry and willingness to participate in developing and applying THz spectroscopy to characterize interstellar ice analogues by revealing the energy relaxation dynamics in amorphous and crystalline ices. Coherent, tunable pulsed IR/THz radiation from FELs is used to pump selected IR/THz vibrational modes in solids, while linear Fourier Transform Infrared spectroscopy probes changes in the bulk of the ice as a function of time. The candidate will also contribute to the design and implementation of pump-probe detection techniques to investigate diffusion, segregation, trapping, reaction and desorption of species in the ice at picosecond timescales.

Qualifications required: Candidates should have a First Class or Upper Second class MSci degree in Physics, Chemistry, Astronomy or related disciplines. Any previous experience in vacuum technology and experimental techniques such as FTIR and THz time-domain spectroscopy and mass spectrometry would be an advantage.